CHAPTER 2: WETLAND FUNCTIONS AND VALUES

CHANGING ATTITUDES

During colonial times, wetlands were regarded as dark, dismal swampy areas that encouraged disease, obstructed overland travel and restricted food and fiber production. Wetlands were viewed as obstacles to development — land that must be drained. As the colonial population expanded, land was cleared and drained to make way for new homes, travel routes and agriculture (Dahl, 1997). Thus, more than half of the estimated 220 million acres of wetlands in the conterminous United States have since been lost, including 4.8 million acres in Indiana. Leading causes of wetland loss in Indiana include conversion for agriculture, **channelization** of streams, construction of seawalls along lakeshores, development for roads, homes, and commercial businesses, and **dredging** for drainage projects.

The cumulative loss of wetlands along with improved understanding of ecological processes led to society becoming more aware of the wealth of benefits wetlands offer. This awareness caused views about wetlands to change considerably. People began to realize that wetlands have both ecological and economic importance. Ecologically, they support numerous plants and animals. In fact, it was discovered that U.S. wetlands support almost 5,000 plant species (U.S. Department of Agriculture, 1995). Economically, some wetlands have provided nearly $200,000 in benefits per acre to a community, according to a Massachusetts study (National Wildlife Federation, 1997). Wetlands provide jobs and consumer goods, and they contribute to the tourism industry.

This new attitude toward wetlands has helped slow their overall loss. This is evident by relatively recent incentives: the passage of the "Swampbuster" provision of the 1985 Food Security Act, the presence of the Clean Water Act Section 404 permit program, growth in state regulatory programs, and implementation of programs like the U.S. Department of Agriculture's Wetland Reserve Program that protect and/or restore wetlands (see Chapter 5 and Indiana Resources for information on regulations and programs). Although the rate of wetland conversion has slowed, wetland losses continue to exceed wetland gains. Also, we still do not have an accurate idea of the quality of our remaining wetlands.

President Clinton's Clean Water Action Plan expands the Bush administration's "No Net Loss" policy by setting a goal to attain a net increase of 100,000 wetland acres per year by the year 2005. The Indiana Wetlands Conservation Plan was designed to "Conserve Indiana's remaining wetland resources, as defined by acreage, type, and function, and restore and create wetlands where opportunities exist to increase the quality and quantity of wetland resources" (Indiana Department of Natural Resources, 1996). As this statement indicates, we need to look at more than just gains or losses of wetland numbers or acreage. Different wetland types provide different values to the watershed and to the communities surrounding it. When a wetland is being degraded or altered from one type to another (i.e., forested to a scrub-shrub) there may be no net loss in acreage, but there maybe a loss of functions performed that were greatly valued by that community. This chapter explains some of the functions that wetlands perform and examines the benefits wetlands offer society. Having an understanding of wetland functions and values can improve current decision-making, which may protect wetland values for future generations.

FUNCTIONS AND VALUES DEFINED

People often confuse the terms "functions" and "values" when it comes to wetlands. A function is any biological, chemical, physical or ecological process operating within a wetland habitat that may or may not benefit humanity. Functions include converting the energy from sunlight into organic matter, releasing nitrogen into the atmosphere and removing **sediments** from water flowing through a wetland. Plants and animals existing in wetland environments are the driving force for these processes. Without healthy plant and animal communities, wetland functions would decline. A value is the benefit provided to humans by the wetland or its functions, such as providing a scenic landscape, water quality improvement, timber harvesting, recreational opportunities and support for commercial wildlife.

It is important to note that although the terms "function" and "value" in many cases are used interchangeably, they are not synonymous. Functions will continue as long as wetland conditions remain constant, but values will change over time (note that wetlands are dynamic systems so functions may shift under natural conditions). New people with differing views may move into a community, people's attitudes may change, and new technologies or interests may develop that result in new or changing perceptions of the importance of a community's wetlands. For instance, if a community experiences unexpected growth leaving only a few remaining wetlands, these wetlands might have an increased value for their green space alone.

WETLAND FUNCTIONS - WHAT DOES A WETLAND DO?

The way a natural wetland functions depends on the location in the landscape, the vegetation types, the source of water and the climate. Wetlands that are isolated from other surface water sources do not have the function of improving water quality downstream, but they may function well as habitat for salamanders. Bogs, for example, do not have high rates of productivity but do function as homes for unique flora, such as the carnivorous pitcher plant which obtains its nutrients from the insects it catches and digests. Wetlands located in regions where precipitation is high could function to hold storm waters and release them slowly, thereby protecting nearby streams from the erosive forces of flash floods. Although an individual wetland can perform many functions, if we try to maximize one function (e.g., retaining sediment, routing floodwaters), other functions will be affected. Some functions may benefit, others could be harmed. Following are some of the more common functions or processes occurring in wetlands.

EAT OR BE EATEN at the Wetlands Cafe

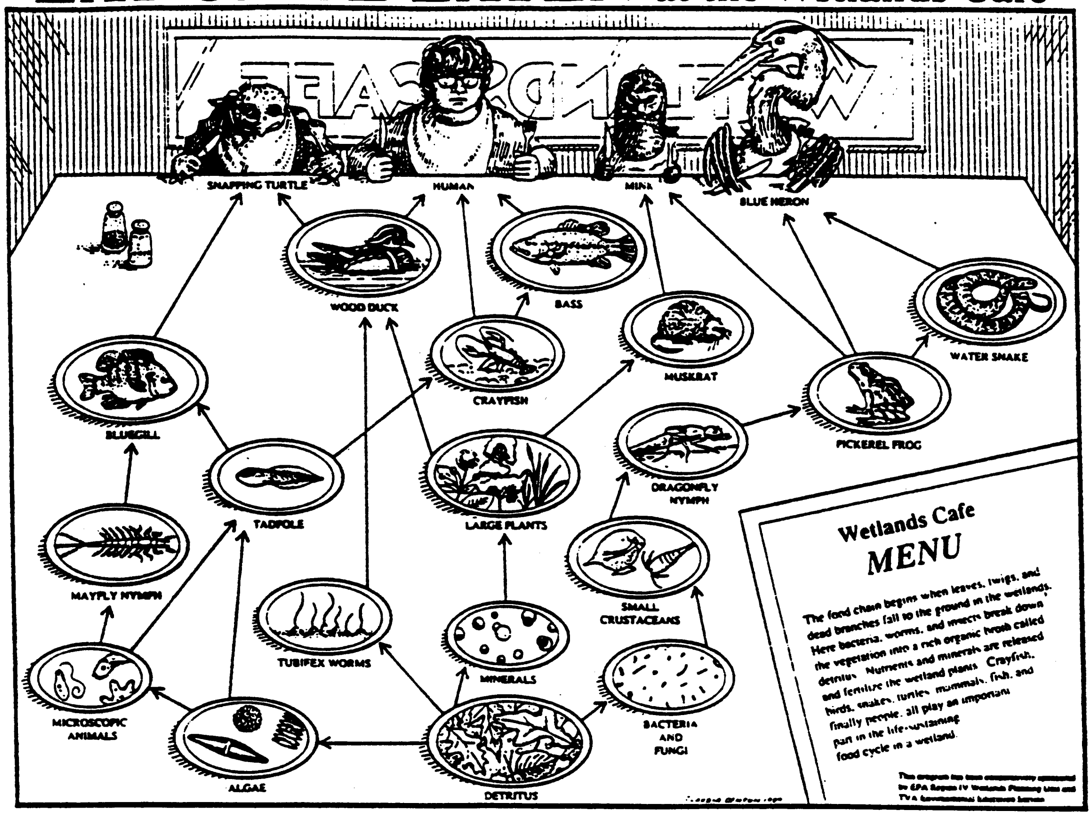

Figure 3-1

Primary Productivity

Nearly all life on earth is ultimately dependent on the production of food energy by primary producers (green plants) in an ecosystem (the exception being life based on geothermal energy near deep-sea vents). In many wetlands, there are two food energy flow patterns or food chains which combine to form **food webs**. The first is the grazing food chain where green plants or algae are consumed. The second is the detrital food chain, which supports organisms that consume **detritus** or decomposing plant parts. All of the uneaten leaves, twigs and dead branches that accumulate in a wetland are broken down by decomposers such as bacteria, worms and aquatic insects producing this energy-rich detritus. The detritus is colonized by microbes that help transform the organic nutrient form into an **inorganic** form, which is more useful to aquatic animals. The resulting food source is highly nutritious and is important for insects, fish and shellfish. These small creatures are eaten by larger ones, such as birds, bigger fish or predatory insects. For instance, in freshwater marshes, aquatic insects are consumed by migratory birds and are critical to their nesting success. All aquatic food sources originate from organic material or detritus, thus wetlands provide the basis for most aquatic food webs (except in situations where planktonic algae form the basis) (see Figure 3-1). In fact, more than 90 percent of the ocean's fisheries depend on the high productivity of shoreline wetlands (Environmental Law Institute, 1992).

Some types of wetlands are more productive than others. Wetlands that have a pulse of inflow and outflow of water are among the most productive. Nutrients can be brought in by flooding along streams and rivers, or made accessible when the water retreats. This pulsing keeps the system oxygenated, which is a critical factor affecting plant growth. It is the reason that floodplains are more productive than bogs, for example, which do not have significant inflows nor outflows (Mitsch and Gosselink, 1993). This pulsing of nutrients is essential to the health of Indiana's waterways including its larger river systems like the Wabash, Ohio, White, Patoka, Whitewater, Kankakee, St Joseph, and Maumee. Manmade levees and dams interfere with this natural cycle and reduce a waterway's productivity.

Groundwater Recharge and Water Storage

Groundwater recharge is "the movement of surface water down through the soil to the underlying groundwater system or aquifer (Niering, 1985). A wetland can act as a groundwater recharge site for an area of land. This depends on the season and amount of precipitation, as well as the type of wetland, its location, soils and relationship to the water table. Groundwater recharge is typical in small wetlands which can contribute significantly to regional groundwater resources.

Urban growth and increasing demands on groundwater supplies highlight the importance of replenishing local aquifers. Wetland plants and soils absorb large amounts of water and thereby slow flows, allowing water to seep into the ground. The capacity of wetlands to store water depends on the soil content and the density of vegetation. Clay soils retain more water than loam or sand since clay pore spaces are small and the water molecules are attracted to the negative charge of clay. Pore spaces between sand particles are large and water drains more freely. As density of vegetation increases, the stems and leaves cause more friction and slow flow velocity. During the growing season, plants take up water and release it into the atmosphere through evapotranspiration. This process reduces the amount of water in the soil and increases the capacity of a wetland to absorb and store additional water from rainfall, snowmelt or floods.

By collecting water during the wet seasons and releasing it at a somewhat constant rate during the dry season, wetlands help maintain more constant surface water flows of streams throughout the year. As pore spaces in wetland soils and peat become saturated with water, their ability to hold water decreases and they release the water more easily, thus adding to the surface water supply. Destruction of wetlands stops these processes and results in **flashy** stream flow with little flow during dry periods and heavier flooding during wet periods.

Biogeochemical Processes

Wetlands can be a source or **sink** (where material is trapped and held) for nutrients, organic compounds and metals; they can also transform these materials. According to the 1997

U.S. Geological Survey's National Summary on Wetland Resources, wetlands are major sinks for heavy metals and sulfur by forming insoluble compounds. Most naturally-occurring soils contain relatively low concentrations of metals, but human disturbances have resulted in metal levels high enough to cause health and environmental risks. Examples of heavy metals are mercury, aluminum, lead, copper, zinc, and selenium. These compounds can cause developmental and behavioral problems. Metals entering wetlands can bind to suspended particles and become buried in wetland substrate and immobilized, thus reducing hazardous risks. In the root zone of wetland plants, bacteria facilitate the uptake of metals from soil; plants then transport these metals to the leaves and stems where most are concentrated. Some of these metals evaporate from the plant into the atmosphere.

The presence of both aerobic and anaerobic conditions in wetlands facilitates the chemical cycling of nutrients, thus preventing pollutants from reaching or accumulating in the water supply. As wetland plants grow, they take up and use inorganic nutrients — nitrogen and phosphorus — from fertilizer runoff and release organic forms of these nutrients (Wohlgemuth, 1993). Because of this, wetlands serve as nutrient storage areas within a watershed. But wetlands do have a saturation point for phosphorus and nitrogen, and once that limit is reached, the excess is exported to adjacent aquatic environments. Also, during the winter season when plants die, nutrients can escape.

Most of Indiana's land surface is used for agriculture. Despite recent improvements in fertilizing technology, farm runoff is still a significant threat to water quality. Wetlands can provide important filtering **buffers** between farm fields and waterways. However, these buffers do not substitute for improvements in land-use practices. Natural wetlands can not be expected to be the primary solution to these pollution problems because water quality will eventually decline if the wetlands become inundated with excess sediments and nutrients.

Wetland soils and root surfaces contain microbial organisms that biodegrade potentially hazardous organic chemicals like **pesticides**. Wetlands also aid in balancing the global nitrogen cycle by taking up excess **nitrates** or other nitrogenous pollutants and releasing them into the atmosphere as a harmless inert gas through a natural process called **denitrification**. In addition, wetlands store sediment and organic matter through filtration and microbial processes. This material serves as an organic energy source for the wetland and, in some cases, for organisms living downstream. Natural microbes found on decomposing wetland vegetation can filter out pathogens like *E. coli*, protozoans, and viruses from our drinking water. Other factors play a role in removing these pathogens including temperature, predation, and sedimentation (Kadlec and Knight, 1996). A natural sedge meadow is being restored in the Indiana Dunes National Lakeshore to filter out bacteria from the water supply and make it safer to swim at the public beaches along the lakeshore (Clean Water Network and Natural Resources Defense Council, 1997)

Within the peat and sediment layers, wetlands can store carbon. This is an important part of the carbon cycle, particularly with today's concerns of global warming and increased levels of carbon dioxide in the atmosphere. Draining wetlands increases the release of carbon dioxide that was stored in the wetland soil, because decomposers can break down organic matter more rapidly once it is exposed to air or increased oxygen. There is also a decrease in absorption of carbon dioxide because there are fewer plants performing photosynthesis. A voluntary effort is underway to reforest parts of southern Indiana, including bottomland hardwoods and riparian areas along large river systems to offset carbon emissions from powerplants and other sources (Hayes, 1999). Indiana's remaining bottomland wetlands are significant carbon sinks. If they are cleared or destroyed, the carbon that was stored in the plant biomass is lost to the atmosphere.

Wildlife Habitat

Wetlands provide shelter, food, and spawning and nesting sites for various birds, fish, mammals, reptiles and invertebrates. They support about 190 amphibian species and one-third of all bird species (Natural Resource Conservation Service Issue Brief, 1995). Almost 43 percent of the federally listed **threatened** and **endangered** animal species, as well as many plant species, in some way are dependent on wetlands for survival (Environmental Protection Agency, 1995). In Indiana, this includes species like the federally-endangered Indiana bat and state-endangered black-crowned night heron. This is remarkable considering that wetlands make up only about five percent of this country's land and only 3.5 percent of Indiana's surface area. In Indiana, 11 species of waterfowl nest in wetlands and 28 species use wetlands for **migration** or wintering grounds. Over 60 animal species and over 120 plant species associated or dependent on wetlands are listed as rare, threatened, or endangered in Indiana or are listed as special concern species, meaning that their population should be closely monitored (Indiana Department of Natural Resources, 1996).

According to Mitsch and Gosselink (1993), all freshwater fish and shellfish are partially dependent on wetlands. Fish change the location and nature of their habitat as they go through stages of development. The young can find protection from larger fish or other predators by staying in the vegetated shallow water of wetlands. There, the nutrients are cycled out of the sand, mud and water, thus made available to these small fish.

Wetlands provide critical habitat for many birds including songbirds, ducks, geese, swans, cranes, and shorebirds. They attract and support many insects such as damselflies, dragonflies, butterflies, spiders and beetles — important components of the food web. Predatory birds such as ospreys, bald eagles, hawks and owls also feed and nest in wetlands. They find turtles, snakes, snails and salamanders on the wetland menu. Muskrat, beaver, river otters, mink, mice and raccoons are some of the fur-bearing mammals that utilize wetlands. White tail deer depend on wetlands for food and shelter, especially during the winter months (Tiner, 1984).

WETLAND VALUES - WHY ARE WETLANDS IMPORTANT TO US?

Wetlands provide numerous benefits to society and actually can protect our property, our safety and contribute greatly to our economy and our quality of life. For these reasons, the development of wetlands is regulated. Our appreciation and value of wetlands first became public in the 1930s when sportsmen recognized the importance of wetlands to waterfowl habitat. They voiced their concerns and Congress responded by enacting laws to protect disappearing wetland resources. Without these **values** expressed by concerned citizens, we would not have the wetland protection we have today.

Usually the value of a particular wetland is an estimate of its importance to the surrounding community. Value can be derived directly from wetland resources such as food, recreation or timber and have dollar amounts associated with them. Values also can be indirect as a result of the natural processes occurring in the wetland as with water purification and flood control. All of the values mentioned in this chapter have economic importance either directly, as with harvesting wetland products, or indirectly, as with the money saved by leaving wetlands that naturally reduce water pollution entering our streams and water supplies. Some communities or individuals value the intangible fact that wetlands are around and may not place a dollar value on them. These people have deep respect and admiration for the natural wetland ecosystems, not for the functions they perform nor the benefits they provide humanity, but simply because wetlands of all types exist.

Just as wetlands can perform multiple functions, some can have multiple values. Differing private and public values may result in conflicts or disputes about wetland uses. Landowners who may not receive any financial benefits from their wetland may place higher importance on bird watching and hunting, for example, than on flood control or water purification. But other local residents may see flood control as the most important value of that wetland. If a private wetland is home to an endangered or threatened species, society - through federal law - places a value on protecting that species and regulates the development of that private land; even though the property owner may value other land uses more.

Particular wetland values change over time and depend on the needs and wishes of those living close to the wetland or those wanting to exploit its resources. Across the nation and abroad, wetlands are valued for commercial benefits, floodwater storage, erosion control, water purification, **intrinsic** qualities, recreational opportunities and educational experiences.

Commercial and Other Economic Benefits

The economy has benefited from wetlands in numerous ways. According to the Natural Resource Conservation Service's Wetlands Values and Trends Issue Brief in 1995, more than half of all adults in the U.S. (98 million people) hunt, fish, bird-watch or photograph wildlife. These activities, which rely in large measure on healthy wetlands, provide millions of dollars to our economy through sales of licenses and purchases of related items such as equipment and travel expenses. In 1996 alone, 37.6 million people traveled to different states just to observe waterfowl, shorebirds, fish, turtles, butterflies and other wetland dependent species (U.S. Department of Interior, 1997). Individual states, like Indiana, gain economic benefits from recreational opportunities in wetlands that attract visitors from other states. Of interest to developers and real-estate agencies, a 1981 study of the Charles River in Massachusetts, found that land values generally are higher when the land is next to wetlands. According to a national survey conducted in 1995 by *Urban Land Magazine*, 77 percent of prospective home buyers want natural open space and 52 percent want wilderness areas as part of their subdivision. In Hamilton County, Indiana, two residential developments including "Winter Cove in the Woods" are located next to wetlands and are popular with the residents because of the scenic beauty and wildlife. More detailed economic analyses need to be conducted for Indiana and the Midwest in order to document the value of wetland conservation to local and state economies. Commercially important products are harvested from wetlands, including fish and timber. Following are examples of how these wetland- dependent industries support Indiana's economy.

Fisheries

More than 95 percent of the commercially harvested fish and shellfish in this country are wetland dependent during some stage of their lives. The commercial fishing industry is a huge contributor to the U.S. economy and provides nearly 2 million jobs nationwide. This value is related directly to the existence and health of our nation's wetlands. Although Indiana may not produce these particular commodities, Hoosiers that consume them should be aware that the supply of these foods requires healthy wetlands elsewhere.

Sport fishing is becoming more popular each year. The U.S. Fish and Wildlife Service determined that recreational anglers in Indiana spent $800 million in 1996 (USFWS, 1998). Although sport fishing has increased, wetlands have decreased by more than 100,000 acres per year nationwide due largely to agriculture and development. If this trend continues, the fish resource will be unable to support the growing number of anglers.

Hunting and Trapping

Throughout history, some communities have relied on the sale of animal furs, skins, and meat for their livelihood. Many of these game animals, such as muskrats, geese and beaver, depend on wetlands to survive. The muskrat is the most widely hunted fur-bearing animal, with about 10 million furs harvested annually nationwide. In Indiana, all the economically-significant furbearing species are wetland-related (Indiana Department of Natural Resources, 1996). Hunting and trapping in wetland areas of the Grand Kankakee Marsh in northwest Indiana produced international trade goods even before Indiana was a state.

According to the U.S. Fish and Wildlife Service, 27,000 people 16 years old and older hunted migratory birds such as ducks, geese and doves in Indiana during 1996. During the year, they spent $5.8 million on equipment and trip-related expenditures including food, lodging and land use fees. Many of Indiana's wetlands support breeding waterfowl and are therefore vital to sustaining the waterfowl population and thus the dollars contributed by waterfowl hunters to the economy.

Wildlife Watching

In 1996, 1.7 million people spent $286 million dollars viewing wildlife in Indiana (USFWS, 1998). They engaged in observation, photography, wildlife feeding, maintenance of natural areas, and visiting public wildlife areas managed by IDNR and others. Some of the more popular species observed are associated with wetlands including waterfowl, river otters, bald eagles, sandhill cranes, and many neotropical migrant songbirds.

Vegetation Harvest

Forested wetlands are a valuable source of wood products. In the mid 1800s, much of the nation's timber came from the swamp forests of Indiana, Ohio, and Illinois, which typically consisted of birch, ash, elm, oak, maple and hickory. Today, the greatest commercially-harvested types of wetland vegetation in the United States are evergreen and hardwood timbers for construction wood and pulpwood. The value of a wetland for timber harvest depends on the wetland type, the value of the trees, the current price of lumber and the size of the tract. Indiana currently ranks third in the nation for hardwood lumber production, with annual revenues of approximately $5 billion (Indiana Department of Natural Resources, 1996). Over half of Indiana's remaining wetlands are forested. This provides a strong potential for continued revenue to the timber industry but only if these areas are protected and harvested in a sustainable manner.

Other states in the Midwest harvest **native** wetland plants for their commercial value including cranberries and wild rice. Peat is a vegetative byproduct of some wetlands. It is harvested in Indiana and elsewhere in the country primarily to produce a horticultural soil additive. Peat is a nonrenewable resource, however, and its harvest destroys the wetland. Grazing and haying of wetland vegetation is crucial to many livestock producers, especially during drought years.

Wetland plants and animals have a great potential for pharmaceutical uses as well. For example, jewelweed (*Impatiens capensis*) stems contain a liquid that can be rubbed onto skin to alleviate the effects of poison ivy or poison sumac. This liquid dissolves the active irritant, urushiol, found in poison plants. Another ingredient of the jewelweed is used as a natural fungicide to treat athlete's foot and itchy scalp. Some Native American tribes and other cultures worldwide recognize the medicinal uses of wetland plants. In many cases, people rely on these plants more than manufactured remedies due to their availability and low cost. Because of the incredible biological diversity found in wetlands around the world, some scientists believe that many vaccinations and medicines have yet to be discovered among wetland plants and animals.

Flood Water Storage

Certain wetlands can protect our property from extensive flood damage during storms and may reduce the need for public spending on flood-control structures or extensive drainage systems. With their dense vegetation, wetlands intercept stormwater flows and slow runoff (see Figure 3-2). Wetland soils, which have better water retention capabilities than upland mineral soils (Novitzki, 1979), absorb flood water and gradually release it. This decreases the velocity and volume of stormwater flows, which prevents stream channels from being scoured and eroded during storms and reduces damage to downstream property. In general, through taxes used for public assistance, the public pays to rebuild areas devastated by storms. These expenses can be reduced if more shoreline wetlands are protected.

Wetlands located along a river are especially valued for their capacity to retain flood water. A classic flood control example is demonstrated through the U.S. Army Corps of Engineers'decision to purchase existing wetlands in the **watershed** in lieu of building expensive flood- control structures on the Charles River near Boston in 1972. The Corps determined that the loss of those wetlands would have caused $17 million in annual flood damage. For the Midwest, a study conducted by a Chicago hydrologist estimated that restoring just half of the original wetlands within the upper Mississippi River basin could have soaked up land stored the flood water in the 1993 flood. This could have potentially saved 50 lives and $15 billion in home and property damage (Hays, 1995). Indiana has lost 85 percent of its original wetlands. This loss contributed to the Ohio River floods in 1997 which caused more than $1 billion dollars in lost homes, businesses, and crops in Indiana and neighboring river states (Sierra Club, 1999). According to FEMA, 18 counties in Indiana have been declared federal flood disasters three times or more between 1988-1996.

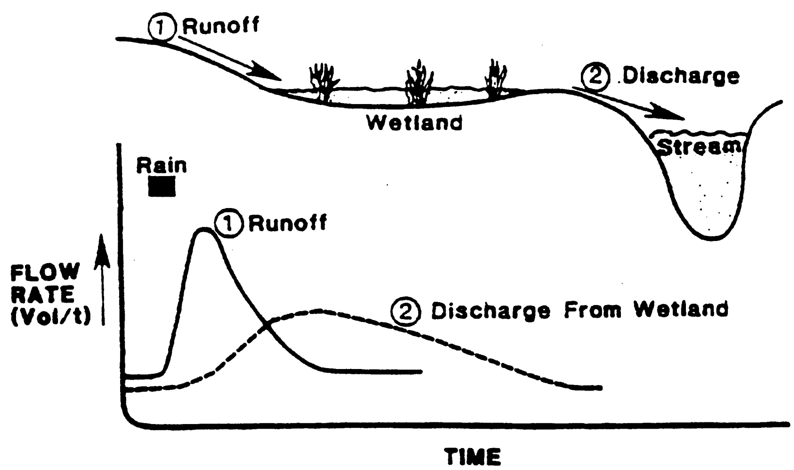

Figure 3-2
Mistch, Gosselink, 1993

Erosion Control

Having natural wetlands as a buffer between property and streams not only reduces peak or flash floods, but also protects the streams from filling with sediment that is transported by the overland flow of water. Sedimentation is the largest problem facing streams across the country according to the States' 305(b) Water Quality Reports to Congress in 1997. According to the Illinois Natural History Survey (1971), siltation was the primary cause of aquatic species reduction and loss in the Midwest.

Shoreline wetlands shield developed shores and dissipate storm energy. They act as buffers against wind, rain and wave action. This makes them valuable protection for shoreline development.Wetlands also diminish the amount of channel erosion that occurs during floods by slowing runoff water. This reduces the amount of sediment pollution entering rivers and lakes. Erosion control is especially important in northern Indiana, where the majority of our public freshwater lakes occur. The Indiana Department of Natural Resources has developed wetland maps for over 90 public lakes that help property owners, developers, and planners avoid damage to significant wetlands along the lakeshores during construction activities.

Water Purification

Wetlands help purify drinking water by naturally filtering polluted runoff from city streets, buildings and agricultural lands. They trap sediments, accumulate nutrients, transform a variety of toxic substances such as pesticides and heavy metals, and can remove potentially dangerous **microorganisms** from surface waters (see Figure 3-3). Society could be faced with

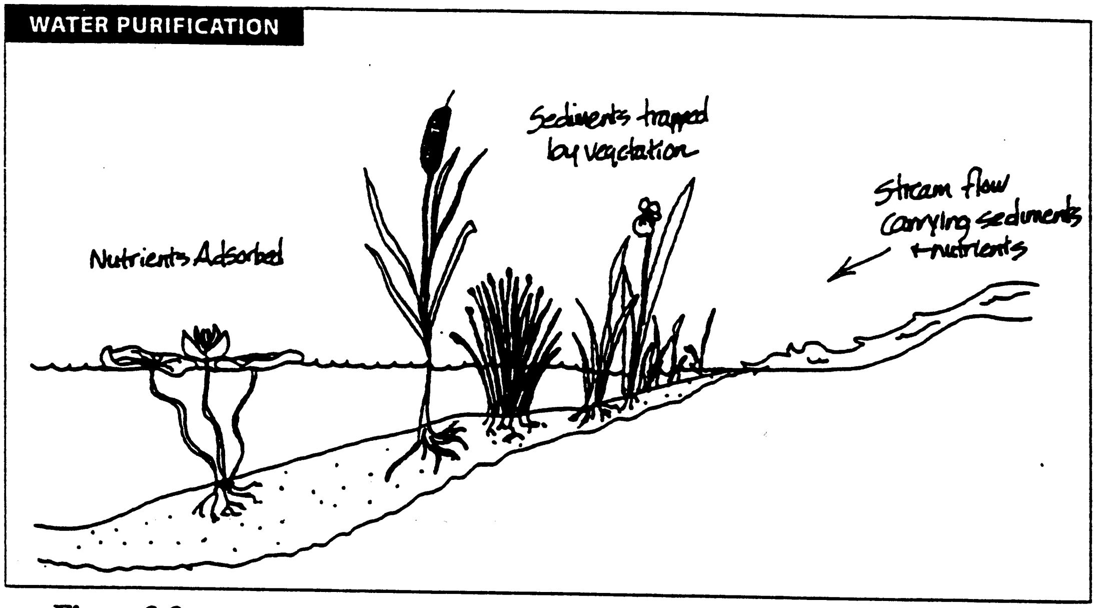

Figure 3-3

significant costs to replace the natural pollution-control functions of wetlands. If half of the nation's existing wetlands were destroyed, 684 million kilograms of additional nitrogen would contaminate our waters. That translates into more than $62 billion per year of sewage treatment plant upgrades in the United States (Husted, 1997).

Constructed wetlands can be a highly efficient, low-cost alternative for treating sewage if engineered properly (Sather and Smith, 1984). Natural wetlands can function in this manner; however, they can be degraded or destroyed in the process. Constructed wetlands for sewage treatment are usually a completely artificial system so the location, design, and operation can be completely controlled. Wetlands for nonpoint source treatment are constructed more often at the base of a drainage where wetlands might have existed over remaining hydric soils. Some of these designs are restored or enlarged natural wetlands that are receiving materials generated in the landscape. Conventional treatment facilities are not designed to remove contaminants such as *Cryptosporidium*, which is thought to be present as a result of polluted runoff. This dangerous contaminant caused more than 100 deaths and more than 400,000 illnesses in Milwaukee during 1993 (Husted, 1997). Partly because of their ability to eliminate these microorganisms, man-made wetlands are being used in the treatment of sewage waste water (Wohlgemuth, 1993). As an added public benefit, microbial action taking place on depressional wetland bottoms may reduce coliform bacteria by 90 percent (Reed and Brown, 1992). Constructed wetlands are increasingly being used across Indiana from Steuben County where one was designed to filter industrial runoffs, to West Boggs Lake in Dubois County where the goal is to intercept agricultural runoff. Small constructed wetland systems are being designed in LaGrange County for treatment of residential waster and replacement of septic systems.

Wetlands in different parts of the watershed improve water quality in different ways. For example, nitrogen processing and retention of large sediment particles might be important functions of natural wetlands that are located near **headwaters**. Phosphorus retention and trapping of fine sediment particles might be a more important natural function in floodplain wetlands further downstream (Mitsch and Gosselink, 1993). Keep in mind that wetlands are delicate ecosystems that have threshold levels for the extent they can perform various functions. So if water were diverted to a wetland from agricultural or urban lands solely for the purpose of retaining large sediment particles, it could harm the natural system and degrade biological communities. A better option might be to construct a detention basin upstream of a wetland. A basin would be easier to maintain and provide higher filtering function. However, because detention basins are usually deeper than natural wetlands, they would not provide similar vegetation or nutrient retention functions as the natural wetland. Other wetlands improve water quality by removing toxic chemicals from the surface water by accumulating layers of peat. The chemicals become trapped with sediment in the peat layers on the bottom of the wetland.

Aesthetics

Many people enjoy the **aesthetic** value of wetlands. As mentioned earlier, property values are higher next to wetlands in many communities because homeowners are willing to pay more for a wetland view. For years, painters, novelists, photographers, poets and musicians have been enchanted by wetlands' diverse beauty and mystery. Flipping through portions of Henry David Thoreau's journals or visiting the National Gallery of Art to view Monet's Water Lilies can inspire nonartists to renew their awe and appreciation of wetlands. Gene Stratton Porter based many of her famous books, like *Girl of the Limberlost,* on the Limberlost Swamp along the upper Wabash River in Adams and Jay Counties. Today, wetland qualities and unique visual characteristics are admired by many. For example, people who might not ever consider visiting a wetland like the Hammer Wetlands Nature Preserve in Noble County are showing their appreciation and support (politically and financially) for preserving these areas. There is a value in just knowing wild and beautiful places such as natural wetlands exist.

Cultural Significance

Often, wetlands are rich in historical and cultural information. Studies of prehistoric Native Americans are supplemented by artifacts found near present day wetlands; artifacts that provide clues to prehistoric lives. In Indiana, the edges of wetlands were highly utilized in the historic past from the earliest recorded human occupation 10,000 years ago. These early people were attracted to the diversity of plants and animals including mastodons that used wetlands. Archeological excavations in Greene County have yielded an especially rich amount of artifacts. The kettle ponds once scattered across the till plains of central Indiana were magnets for people because water was otherwise limited in this area. Later, the Mississippian cultures were strongly associated with the floodplain wetlands of the Ohio and Wabash Rivers in southwest Indiana (McCullough, 1999).

Recreational and Educational Opportunities

Wetlands provide great diversity and beauty simply for visual enjoyment. They provide endless opportunities for popular recreational activities such as hunting, canoeing, bird watching and hiking. In a poll conducted by the President's Commission on Americans Outdoors, it was found that natural beauty was the single most important feature tourists considered when selecting a site for outdoor recreation (Frost, 1992).

Wetlands are perfect "outdoor laboratories." Students of all ages can learn about nature and this specialized habitat firsthand through school tours, outdoor classrooms and the use of nature trails. Schools can adopt a local wetland or restore an existing site on the school grounds. The complexity of these ecosystems makes them excellent subjects for research projects such as vegetation surveys, water quality or wildlife studies. Many wetland preserves offer field trips for classes, guided nature walks and interpretive displays to introduce the public to wetland experiences.

For instance, at the 15,000-acre Indiana Dunes National Lakeshore and the 2,000-acre Indiana Dunes State Park, both of which are in Porter County, 2.6 million visitors each year learn about wetlands on the properties' nearly 10,000 acres of freshwater marsh, swales, sedge meadows and bog habitat. On an annual basis, more than 57,000 school children visit the lakeshore, nearly 1,000 programs are offered to the public and over 400 volunteers participate in wetland education, research and management activities (Indiana Dunes National Lakeshore, Indiana Dunes State Park, 1999). The Muscatatuck National Wildlife Refuge in Seymour, Indiana, which has 1,200 acres of "managed waters", provides self-guided wetland interpretive trails and wetland education programs for more than 185,000 visitors annually. These wetlands include open water, "green tree reservoirs" (**diked** lowland forests that are flooded in the fall for waterfowl feeding and nesting areas and drained in the spring to keep the trees healthy) and "moist soil units" (low open areas surrounded by dikes that are filled with water in the fall and drained in the spring to provide feeding areas for waterfowl and shorebirds) (USFWS, 1998).

In addition to the educational programs offered by staff at these wetland preserves, several environmental organizations in Indiana lead guided tours of various wetlands throughout the state. Some of these groups include the Sierra Club, ACRES Land Trust, The Nature Conservancy, Audubon Society, and Save the Dunes Council. Outdoor labs focusing on wetland ecology are being developed by local and state government including the Indiana Department of Environmental Management.

In Indiana, there are over thirty dedicated nature preserves managed by the Indiana Department of Natural Resources - Division of Nature Preserves - that represent a spectrum of high-quality wetlands, including fens, bogs, swales, and cypress sloughs. The IDNR Division of Fish and Wildlife manages a system of Wetland Conservation Areas that border many of Indiana's natural lakes. These public areas are preserves to be used for hiking and nature study activities.